Real World Design – National Challenge

Challenge Definition:

Student teams will design a supercritical wing optimized for minimum drag when cruising at Mach 0.95 at an altitude of 37,000 feet.

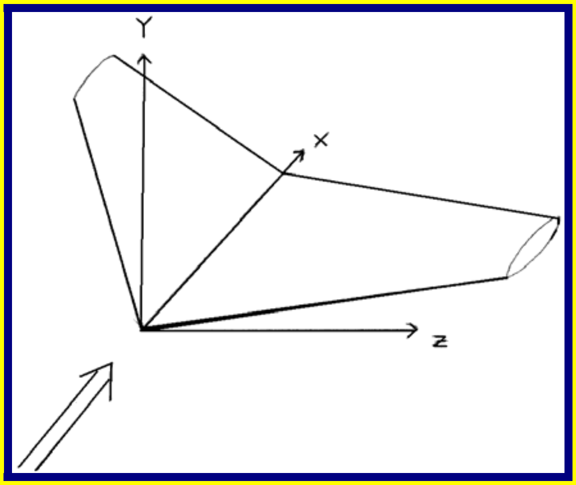
Partial List of Design Variables:

- **Wing Planform:**
  - Wing planform area
  - Wing root chord length
  - Wing tip chord length
  - Wing span
  - Sweep of wing along the leading edge
  - Wing taper from root to tip
  - Wing twist from root to tip, etc.
- **Airfoil Selection(s):**
  - Constant airfoil same section from root to tip
  - Vary airfoil section along the span

Student Designs *MUST* Reflect the Following Design Requirements:

- **Clean Wing Design**
  - No high lift devices (flaps, slat, etc)
  - No winglets, fuselage, empennage, pylons, nor nacelles
- **The Airfoil Thickness to Chord Ratio (t/c) Shall be At Least 8.0%**

The geometry of the design is shown in the diagram below.



The following specifications must be met:

- **Although teams will not incorporate a fuselage, tail section, engines, or other airplane parts into their solution, the total lift generated by the wing must be sufficient for incorporation into an aircraft. For this reason, the total aircraft weight (W) shall be a function of the wing planform area (S) as follows: W = 15000 lbs + S x 7.7 lbs/sq-ft,**

- **Aircraft speed shall be Mach 0.95 (free stream velocity) at 37,000 ft, Standard Atmosphere,**

- **Lift must equal weight, and**

- **The design will reflect a rigid wing (no geometric deflection under aerodynamic load).**

Recommended Design Sequence

I. Research and select candidate airfoil sections for the design condition.

II. Size the wing area and set angle of attack to approximately balance lift and weight.

III. Use ProEngineer or other CAD software to construct the wing geometry.

IV. Complete a computational fluid dynamic analysis of the wing. As in the State Challenge, you can save computational time by analyzing a half wing (left or right) and apply the principle of mathematical symmetry to get full span results.

V. Chart input design parameters versus lift, weight, and drag at each design iteration.

VI. Document design decisions.

VII. Continue design optimization iterations to target minimum drag and arrive at a balance of lift and weight.

VIII. Convergence Analysis - At the end of the optimization iterations, review computational convergence by making two or three additional runs while varying grid density, and again while varying the number of analysis time steps. Plot lift and drag results versus grid density and the number of analysis time steps to estimate computational accuracy. Review the references provided below for more discussion and examples of real world CFD convergence studies:

a. http://www.nafems.org/resources/CFDConvergence/
b. http://aaac.larc.nasa.gov/tsab/cfdlarc/aiaadpw/Workshop3/presentations/S2-Sclafani-Case1.pdf
c. http://aaac.larc.nasa.gov/tsab/cfdlarc/aiaa-dpw/Workshop3/presentations/S7-Sclafani-Case2.pdf

Deliverables

Each student team will create two products that will be used to evaluate their National Challenge entry. The essential features of these products are outlined below, additional information on the judging process will be provided separately.

I. Each team will create a Design Notebook that documents the teams design process and presents their solution to the National Challenge. The Design Notebook will be delivered electronically through the Windchill software interface no later than Wednesday, March 18th, 2009 at 12:00 midnight. There is no minimum or maximum limit to the size of the Design Notebook.

However, the Design Notebook MUST include:

a. A Cover Page With:

- i. The Team Name,
- ii. The Drag Coefficient for the submitted design, and
- iii. A visual representation of the final design.

b. A Narrative Description of the Design Process, Including:

- i. Diagrams of the wing planform with a table summarizing design variable values.
- ii. Design variables investigated and used.
- iii. Airfoil selection(s) with a table of section coordinates.
- iv. A discussion of the decision making process that highlights both the design process and the results of that process.
- v. Charts or other representations showing the relationships among key design parameters and weight, lift, and drag results.
- vi. A review of the convergence analysis with an assessment of the quality of the final design results.

II. On Saturday, March 20th, each team will make a presentation before a panel of judges at the National 4-H Center. Each 20 minute presentation will be followed by a 15 minute question and answer session. Student teams will provide an electronic copy of all visual materials associated with their Design Presentation to the National Judging Director upon arrival at the National 4-H Center on Friday, March 20th.

This Presentation should:

a. Present the team's results in a clear, straightforward manner,
b. Include a description of the design process,
c. Reflect a clear understanding of the scientific and technical issues involved in arriving at a solution,
d. Discuss the importance of iteration in the design and testing processes,
e. Highlight innovations in the team's process or design,
f. Present information in a logical, uncluttered format, and
g. Describe the role and contributions of each team member.